SLT-B solutions:

1/ a/ Characteristic impedance is the scalar that shows the relation between $\vec{E}$ and $\vec{H}$ field magnitudes in a medium. As vacuum is also a medium and has ϵ and μ, it has characteristic impedance.

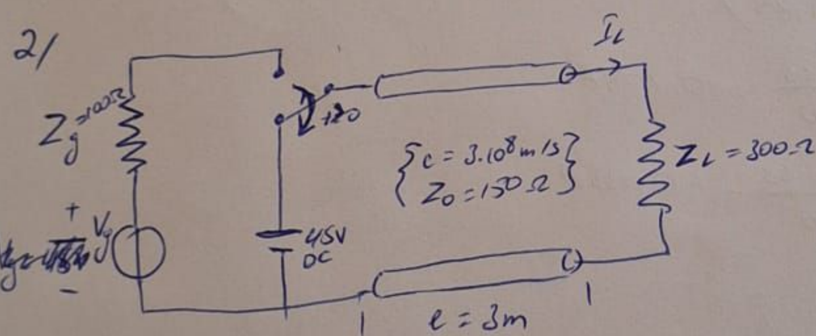
b/ This signifies that at given frequencies, materials are more absorbant of the EM waves. For example, a material's atoms may be as big as the wavelength, making them absorb the energy and get heated up - water and microwave.
It really depends on material and frequency, as the material may be fully absorbing the wave or fully resonate with it and practically to have zero effect to the wave propagation.

c/ Standing wave ratio = $\dfrac{1+|\Gamma|}{1-|\Gamma|}$.

In the case of SC: $\Gamma = 1 \rightarrow SWR = \frac{1+1}{1-1} = \frac{2}{0} = \infty$

$\Rightarrow$ yes, it is possible, at SC termination.

2/

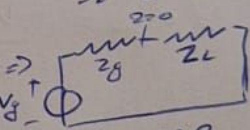


at $t<0 \rightarrow V_g$

at $t>0 \rightarrow$ 45V across line

a/ at steady state

$I_L = 60$mA



$Z_g = 100\,\Omega$

$\Rightarrow V_g = (Z_g + Z_L)\cdot I_L =$
$= 400 \cdot 60 \cdot 10^{-3} =$
$= 24V$

b/ $\begin{pmatrix} V_{ss}^+ \\ V_{ss}^- \end{pmatrix} = \frac{1}{2}\begin{pmatrix} 1 & Z_0 \\ 1 & -Z_0 \end{pmatrix}\begin{pmatrix} V_{ss} \\ I_{ss} \end{pmatrix} =$

$= \frac{1}{2}\begin{pmatrix} 1 & 150 \\ 1 & -150 \end{pmatrix}\begin{pmatrix} 24 \\ 0{,}06 \end{pmatrix} =$

$= \begin{pmatrix} 16{,}5 \\ 1{,}5 \end{pmatrix}$

$I_{ss}^+ = \frac{V_{ss}^+}{150} = 110$mA

$I_{ss}^- = -\frac{V_{ss}^-}{150} = -50$mA

c/ at $t = 0^-$

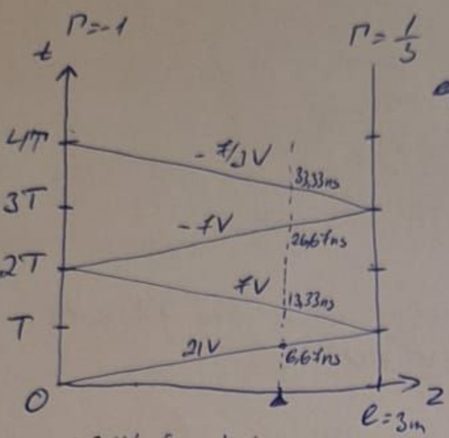
$\rightarrow V_{z=0} = V_g \cdot \frac{Z_L}{Z_L + Z_g} = 24 \cdot \frac{300}{400} = 18V$

at $t=0 \rightarrow$ switches $\rightarrow$ 45V directly injected at node $\Rightarrow$ at $t=0$; $z=0$, we have

d/ @ $t=0^+$, $\hookrightarrow |V_{comp}| = |45 - V_g| =$
$= 21V$

3/

a/



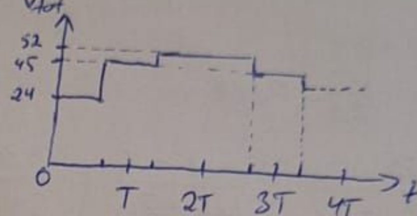
+24V from before

a/ $c = 3.10^8$ m/s

$\ell = 3m$

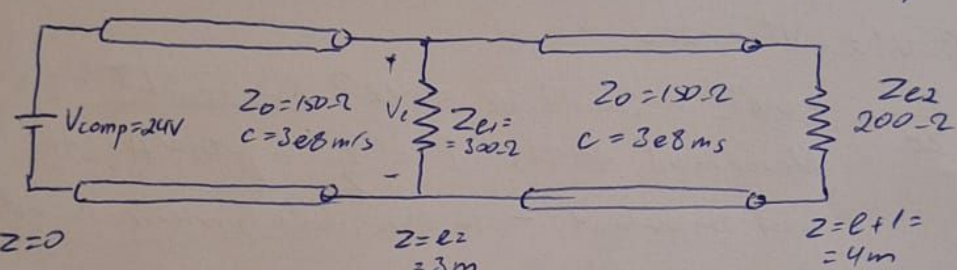
$T = \frac{\ell}{c} = 10ns$

b/ V_{total} @ $t = 2m$:



After 33,33 ns → $V_{tot} = 42{,}67V$
after that, not requested

c/



$\Gamma_0 = -1$; $\vec{\Gamma}_{z=\ell} = \frac{Z_{11} - Z_T}{Z_{11} + Z_T}$ ⇒ $Z_{11} = (Z_{e1} \| Z_0) =$

$= \frac{300.150}{450} = 100\Omega$

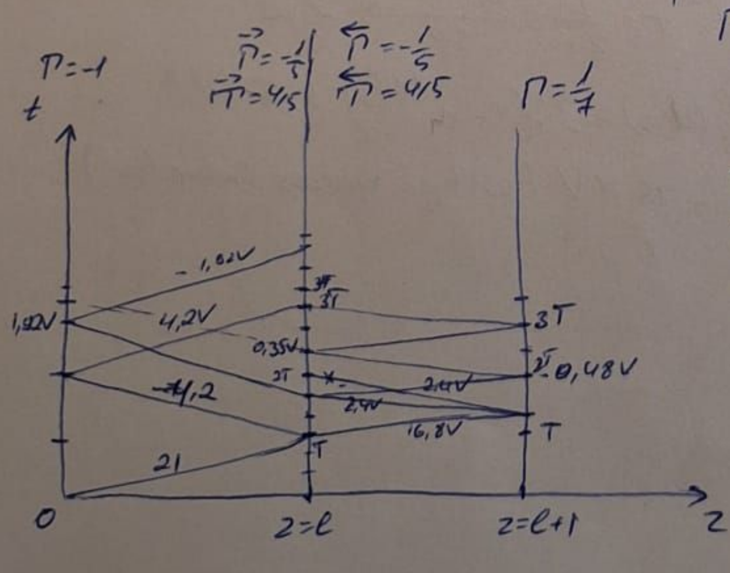
$= \frac{100-150}{250} = -\frac{1}{5}$

$\vec{T}_{z=\ell} = \frac{4}{5}$

$\Gamma_{z=\ell+1} = \frac{200-150}{350} = \frac{1}{7}$

$\overleftarrow{\Gamma}_{z=\ell} = \vec{\Gamma}_{z=\ell}$ (same TL CharImp)

$= -1/5 \Rightarrow \overleftarrow{T}_{z=\ell} = \vec{T}_{z=\ell}$

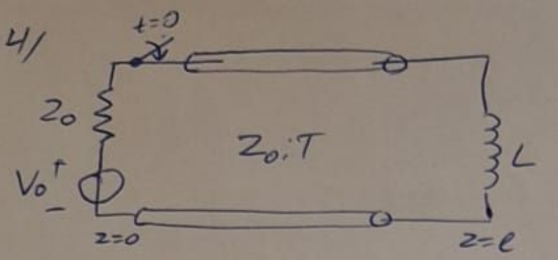


$T_1 = 10ns$

$T_2 = 3{,}33ns$

I am not finishing the smaller voltages, fuck that, derive them on the go, you have the Γ and T coeff.

4/



$V_0 = 20V$
$Z_0 = 50\Omega$
$T = 1\mu s$

a/ at $z=0$; $t=0^+$, there is a wave travelling across the TL with magnitude 20V
There are no reflections yet, so $V = V^+ + V^- = V^+$
$\Rightarrow V^+ = 20V$
$I^+ = \frac{V^+}{Z_0} = 0{,}4A$

b/ $\Gamma_{z=L} = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{j\omega L - Z_0}{j\omega L + Z_0} = \frac{j.0.L - Z_0}{j.0.L + Z_0} = -1$ | $\omega = 2\pi f \Rightarrow DC \rightarrow f = 0$

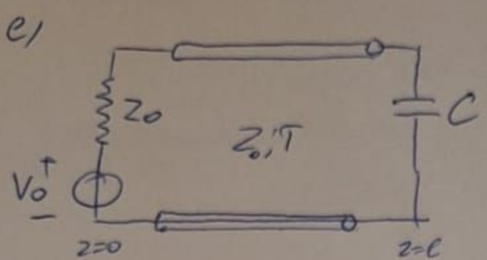
not getting what it means when reaching steady state to derive again Γ_L

c/ $V^- = \Gamma.V^+ = -V^+ = -20V$
$I^- = -\frac{V^-}{Z_0} = 0{,}4A$? -> Should be $-0{,}4A$? Ask on SLT
Nevermind, ~~it~~ its $I^- = \frac{V^-}{Z_0} = -0{,}4A$, the most important - in the whole universe is not here.

d/ $W_L = \frac{1}{2}L.I^2 = V^+.I^+$ ...
Something tells me of the inductor getting energy and dropping the voltage initially.. But impedance is 0, but there is also $\frac{dI}{dt} > 0$ at $t = 1\mu s$...
~~$W_L = \frac{1}{2}.(0{,}1.10^{-3}) I$~~ ~~Ask at SLT, how go with math~~
Ok, so inductor does take time to charge up, aka consumes energy. This takes 5τ with τ being the effective time constant. $\tau = \frac{L}{Z_0} = \frac{0{,}1.10^{-3}}{50} = 2\mu s$

$I_L(t) = \frac{V_0^+}{Z_0}\left(1 - e^{-t/\tau}\right) \Rightarrow I_L(1\mu s) = I^+\left(1 - e^{-\frac{1.10^{-6}}{2.10^{-6}}}\right) = 0{,}157A$

$V_L = L\frac{di}{dt} = (0{,}1.10^{-3}).\frac{I_L}{T/2} = 15{,}7V$ (voltage across inductor) e/

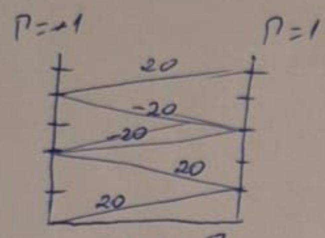


$$\Gamma_L = \frac{Z_C - Z_T}{Z_C + Z_T} = \frac{\frac{1}{j\omega C} - Z_T}{\frac{1}{j\omega C} + Z_T} = 1$$

$V^+ = 20V$ $I^+ = \frac{V^+}{Z_T} = 0,4A$

$V^- = V^+ \cdot \Gamma = 20V$ $I^- = \frac{V^-}{Z_T} = 0,4A$

For miself



oscillates?

↳ something is not right + cant draw diagram in that case?, tho

At $t \to \infty$, steady state

$V_{z=\ell} = 20V$

$I = 0$

$$\begin{pmatrix} V_{ss}^+ \\ V_{ss}^- \end{pmatrix} = \frac{1}{2}\begin{pmatrix} 1 & 50 \\ 1 & -50 \end{pmatrix}\begin{pmatrix} 20 \\ 0 \end{pmatrix} = \begin{pmatrix} 10 \\ 10 \end{pmatrix}$$

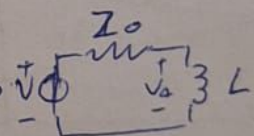
$I_{ss}^+ = 0,2A$

$I_{ss}^- = -0,2A$

$V_C = \frac{Q}{C} = \frac{I \cdot t}{C}$; electrons are gonna be pushed in cap, until V_C goes to V_0, and then start reflecting wave?

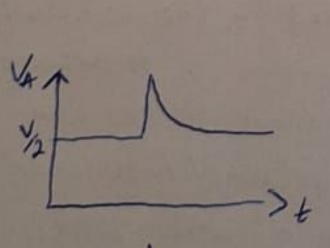
OK correction to all. Based on pdf I found online, inductor initially acts ~~and~~ as open circuit, so $\Gamma = 1 \to V^- = V^+$ and then eventually acts as short.

Inductor time constant: $\tau_L = \frac{L}{2Z_0}$? →

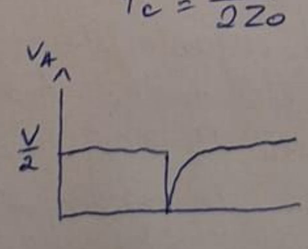


For capacitor, initially is SC, eventually ~~op~~ OC.

$$\tau_C = \frac{C}{2Z_0}$$



L



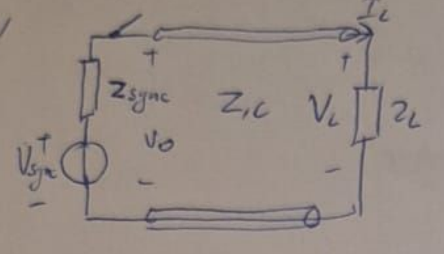
C

← for sufficiently fast transit times

5/ a/ Several reasons:

1. Mechanical damage over the transport of the clocks.
2. Each clock ~~has~~ that is mechanical is a bit off, and need calibration.

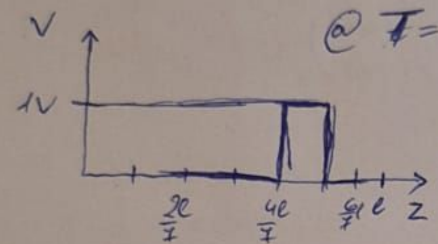
b/



$T = 1ms$
$V_{sync} = 1V$
$Z = 50\Omega$
$c = 2 \cdot 10^8 m/s$
$\ell = 1400km$
$Z_S = Z_{sync} = 100\Omega$

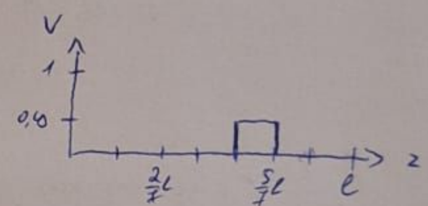
$t = \frac{\ell}{c} = 7ms$

@ $T = 5s$

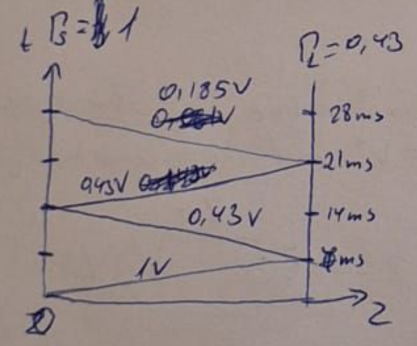


- just a single pulse?

c/ $\Gamma_L = \frac{125-50}{175} = 0,43$ ->



d/

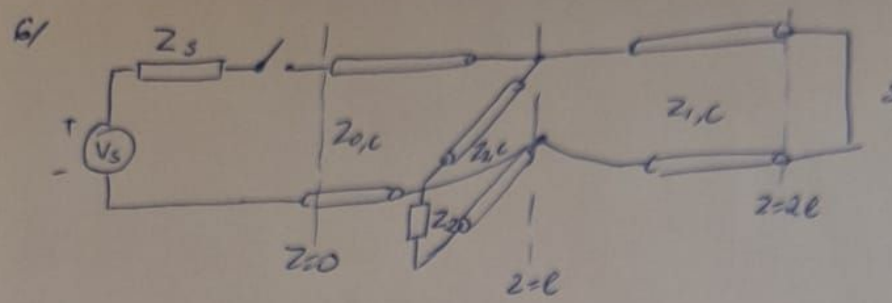


~~$\Gamma_S = \frac{100-50}{150} = \frac{1}{3}$~~ $\Gamma_S = 1$

e/ $\sum_{n=1}^{\infty} 0,43^n < 1$

Well, we can match all characteristic impedances in the network, so reflections are ~~eth~~ eliminated. Another option is, ~~because~~ to have all stations with $\Gamma_L < 0,5$, meaning those pulses can never add up to 1, aka only register with pulse amplitude over 1V. Making the ~~pa~~ Γ_L even smaller will guarantee a better SNR.

6/



$V_s = 9V$
$Z_0 = 300\,\Omega$
$Z_1 = 150\,\Omega$
$Z_2 = 400\,\Omega$
$Z_S = 50\,\Omega$
$\ell = 450m$
$c = 3\cdot 10^8$; $t = \frac{\ell}{c} = 1{,}5\mu s$

a/ $V_{SS,z=0} = V_{SS,z=\ell} = V_{SS,z=2\ell} = V_s \cdot \frac{Z_2}{Z_s + Z_2} = 9 \cdot \frac{400}{450} = 8{,}14V$

b/ $V_{comp} = \frac{V_g - 0}{2} = 4{,}5V$

c/ $\Gamma_{z=0} = \frac{Z_S - Z_0}{Z_S + Z_0} = \frac{50-300}{350} = -\frac{6}{7}$

$\Gamma_{0\to 12} = \frac{(Z_1 \| Z_2) - Z_0}{(Z_1 \| Z_2) + Z_0} = \frac{109-300}{409} = -0{,}467$ $\quad T_{0\to 12} = 0{,}533$

$\Gamma_{1\to 02} = \frac{(Z_0 \| Z_2) - Z_1}{(Z_0 \| Z_2) + Z_1} = \frac{171-150}{321} = 0{,}065$ $\quad T_{1\to 02} = 1{,}065$

$\Gamma_{2\to 10} = \frac{(Z_0 \| Z_1) - Z_2}{(Z_0 \| Z_1) + Z_2} = \frac{100-400}{500} = 0{,}6$ $\quad T_{2\to 10} = 1{,}6$ | $\Gamma_2 = \frac{Z_2 - Z_2}{Z_2 + Z_2} = 0$

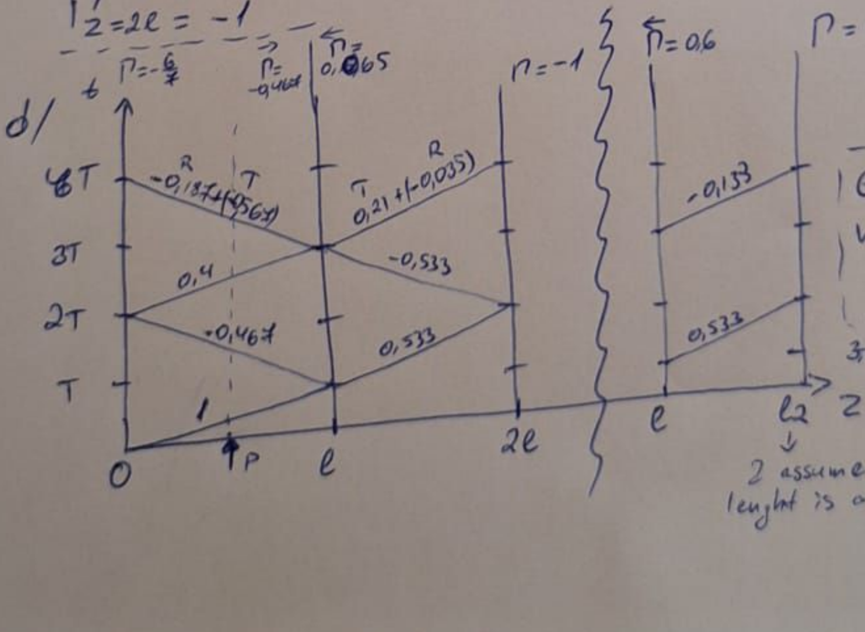
@ Z_2 section

$\Gamma_{z=2\ell} = -1$

Done in units ↙

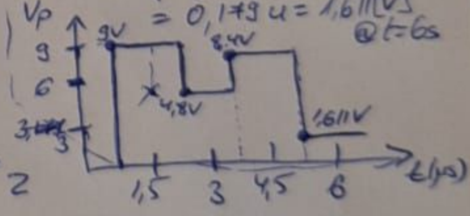
$1u = 9V$

d/



2 assume lenght is also 2ℓ but in other direction

e/ $V_P = 1 - 0{,}467 + 0{,}4 + (-0{,}187 - 0{,}507) = 0{,}179u = 1{,}611[V]$ @ $t = 6s$



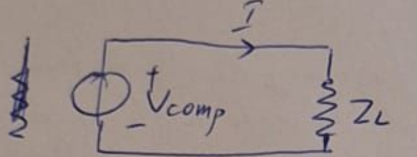
e/ 45V battery char. impedance = $Z_{G45} = 0$ (Short Circuit)

$\Rightarrow \Gamma_{z=0} = -1$

$$\Gamma_{z=\ell} = \frac{Z_L - Z_T}{Z_L + Z_T} = \frac{300-150}{450} = \frac{1}{3}$$

f/ As the line is already at 24V from $t<0$, a wave with V_{comp} will only propagate along the TL. In that case, if the reference is taken at potential of point of 24V, we can ignore the existing voltage and treat it as a propagating wave of 21 V.

$\rightarrow$



$V_{comp} = 21V$ DC

$Z_L = 300\,\Omega$

$\Rightarrow I = \frac{V_{comp}}{Z_L} = 70mA$

$$\begin{pmatrix} V_{c,co}^{+} \\ V_{c,co}^{-} \end{pmatrix} = \frac{1}{2}\begin{pmatrix} 1 & Z_0 \\ 1 & -Z_0 \end{pmatrix}\begin{pmatrix} V_{comp} \\ I \end{pmatrix} =$$

$$= \frac{1}{2}\begin{pmatrix} 1 & 150 \\ 1 & -150 \end{pmatrix}\begin{pmatrix} 21 \\ 0{,}07 \end{pmatrix} =$$

$$= \begin{pmatrix} 15{,}75 \\ 5{,}25 \end{pmatrix}$$

$$I_{c,co}^{+} = \frac{V_{c,co}^{+}}{Z_0} = 0{,}105A$$

$$I_{c,co}^{-} = -\frac{V_{c,co}^{-}}{Z_0} = -0{,}035A$$